

# INFLUENCE OF FUNGAL ENDOPHYTE INFECTION IN TALL FESCUE AND PERENNIAL RYEGRASS ON SOIL CARBON SEQUESTRATION AND LITTER DECOMPOSITION IN LOW INPUT TURFGRASS SYSTEMS

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## ABSTRACT

Turf type tall fescue (*Festuca arundinacea* Schreb) and perennial ryegrass (*Lolium perenne* L.) are commonly used for lawns and golf courses in the Northeast and Midwestern United States. These species differ in growth habits, drought tolerance, resistance to herbivory, and form mutualistic associations with *Neotyphodium* endophytes (Clavicipitaceae). Therefore, we hypothesized that the grass species will differ in the amount of soil organic carbon C sequestered and the endophyte infection will also influence C sequestration. Plots with low (<30% of plants) and high (80-95%) endophyte infection levels were established in 1999 and were managed by mowing, without any fertilizer and pesticide inputs. In 2006, soil organic C (SOC) and its labile fractions, including microbial biomass C (MBC) and dissolved organic C (DOC) pools were measured separately for depths 0-30mm, 30-60mm, 60-90mm, and 90-120mm. Litter bags were incubated on site to determine the effect of the endophyte on decomposition of grass clippings. C pools did not differ significantly between the four treatments and averaged 25.9(±1.8) Mg ha<sup>-1</sup> SOC, 305.2(±23.1) kg ha<sup>-1</sup> MBC, and 62.7(±5.4) kg ha<sup>-1</sup> DOC in 0-120mm depth. In all treatments, greater SOC and MBC pools (p<0.001) were present in 0-30mm depth as compared to lower 3 depths. Litter bag extractions showed that the proportion of remaining leaf litter was the same in all treatments and times except for the second, third, and fourth sampling dates. We conclude that carbon sequestration was not influenced by either the grass species or endophyte level during the studied 7 year period.

## INTRODUCTION AND SIGNIFICANCE

- ❖ Capturing and securely storing CO<sub>2</sub> (Carbon sequestration) is one of the major environmental goals to mitigate the effect of global climate change.
- ❖ There are about 20 million (M) hectares of irrigated turf excluding 12 M kilometers of roadside and 33 M hectares of National Park Service land in U.S.A. (Welterlen, 2003) that can serve as a reservoir of terrestrial carbon.
- ❖ Carbon (C) sequestration in turf soils can occur at a rate similar to that occurs in land that has been placed in the Conservation Reserve Program (Qian and -Follet, 2002).
- ❖ Endophytes can provide competitiveness, drought tolerance, and insect and disease resistance to grasses by the production of toxic alkaloids (Latch, 1997).
- ❖ Franzluebbers and Hill (2005) demonstrated the persistence of ergot alkaloids in soil under forage type endophytic tall fescue and demonstrated reduced microbial biomass and activity.
- ❖ Data on the effect of grass species tall fescue and perennial ryegrass and their mutualistic endophytes that produce toxic alkaloids on soil C dynamics in turfgrass systems is lacking.

## HYPOTHESIS

- ❖ The grass species will differ in the amount of soil organic carbon C sequestered, and the endophyte infection will also influence C sequestration.

## OBJECTIVES

- ❖ To investigate the effect of endophyte infection in turf type tall fescue and perennial ryegrass on soil organic carbon (SOC) and its labile fractions including microbial biomass C (MBC), and dissolved organic C (DOC).
- ❖ To determine the effect of the endophyte on decomposition of grass clippings.

## DESIGN APPROACH

**Question:** Turfgrass plots -- Grass species / Endophyte Infection

**Method:** Soil analysis for SOC, MBC, DOC / litter decomposition

**Answers:** Grass species and/or endophyte infection with greater C sequestration

## MATERIALS AND METHODS

- ❖ Sixteen 6.1 × 6.1 m plots with low (<30% of plants) and high (80-95%) endophyte infection were established in 1999, 4 each of tall fescue (TF- and TF+) and perennial ryegrass (PR- and PR+).

- ❖ Managed only by mowing, no fertilizers and pesticides applied.

- ❖ Soil -- Wooster silt-loam.

## SOIL ANALYSIS

- ❖ Twenty soil cores (2 cm dia and 15 cm deep) were obtained randomly from each plot in August 2006.
- ❖ Soil cores divided into 0-3, 3-6, 6-9 and 9-12 cm depths.
- ❖ Soil bulk density (pb) determined by core method.
- ❖ Total % Carbon (TC) quantified by combustion under oxygen supply and high temperature.
- ❖ Soil microbial biomass C estimated using Fumigation-extraction method.
- ❖ Dissolved Organic Carbon estimated by DI water extracts for C analysis using high temperature combustion.
- ❖ SOC, MBC, and DOC pools were calculated using the following equation (Lal *et al.*, 1998)  

$$\text{SOC (Mg ha}^{-1}\text{)} = [\% \text{TC} * \text{Bulk Density (Mg m}^{-3}\text{)} * \text{Soil Depth (m)} * 10^4 \text{ (m}^2 \text{ ha}^{-1}\text{)}] / 100$$

## LITTER DECOMPOSITION

- ❖ Bags made of fiberglass, 10 cm × 10 cm, 1mm × 1mm mesh size were filled with samples of oven-dried (60° C) grass clippings from each plot.
- ❖ On 6 June 2006, litter bags were laid randomly below the soil surface, extracted on 6 different dates, and analyzed for remaining leaf litter.
- ❖ Extracted litter mass was corrected for soil contamination before determining mass loss to obtain litter fraction (Blair, 1988)
- ❖ Proportion of remaining litter at time *t* was calculated as the product of remaining litter mass and the sample fraction that is litter.

## RESULTS

### SOIL ANALYSIS

- ❖ Soil pH < 7.2 in all treatments, therefore the TC was considered as SOC.
- ❖ The soil bulk density did not differ between treatments and so an average value (0.93, 1.28, 1.29, and 1.28 Mg m<sup>-3</sup>) for each depth was used for the carbon pool calculations.

Figure 1. Soil organic carbon pools at various soil depths

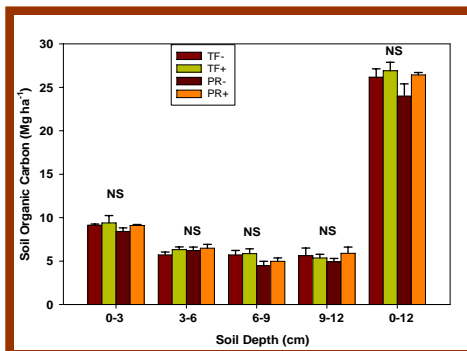


Figure 2. Soil microbial biomass carbon pools at various soil depths

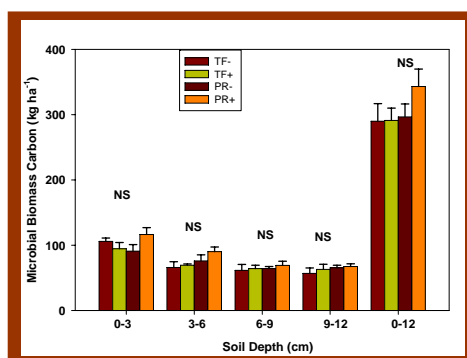
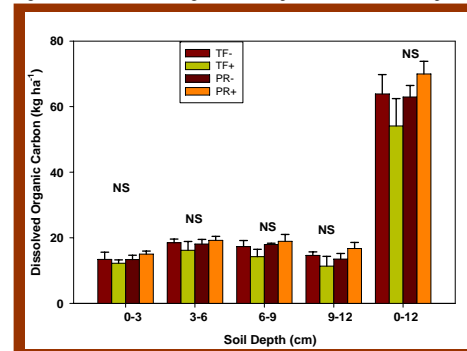


Figure 3. Soil dissolved organic carbon pools at various soil depths



PROC GLM (SAS). NS - Not significant at  $p < 0.1$  and  $p < 0.05$ . Error bars indicate Standard Error of Mean.

## RESULTS...

### LITTER DECOMPOSITION

- ❖ Leaf litter decomposed significantly slower in tall fescue, intermediate in PR-, and significantly faster in PR+, after 7 days decomposition ( $p < 0.1$ ) and after 14 and 21 days decomposition ( $p < 0.05$ ).
- ❖ There was no difference between treatments from days 35 to 63.

## DISCUSSION AND CONCLUSION

- ❖ This is the first study to quantify the SOC pools in soils under low maintenance turf grass species with low and high endophytic tall fescue and perennial ryegrass at various depths as per our knowledge.
- ❖ Franzluebbers and Stuedemann (2005) analyzed SOC pools in TF low (<7% of plants) and high (80%) in a Cecil sandy loam soil pasture in Georgia, and concluded that endophyte effects on SOC pools were significant only under conditions of high fertility. Absence of fertility in our treatments may be a reason for non significant differences in SOC pools between grass species as well as endophyte infection in our study.
- ❖ Significantly higher pool of SOC and MBC in the top 0-3 cm depth as compared to the lower 3 depths indicates rapid decomposition of grass clippings at this depth closest in contact with mowed grass clippings. This depth should be more closely examined for alkaloid presence and content in turfgrass system.
- ❖ Dissolved organic C is the source of energy for microorganisms. Absence of significant differences between treatments for this labile C fraction further supports the results for MBC that soil microbial community is not negatively affected by grass species or the presence of endophyte.
- ❖ Buried litter bags were in close contact with the soil microorganisms and therefore no change in decomposition between treatments after day 35 indicates that the alkaloids did not have any effect on the decomposing soil biota.
- ❖ The initial significant difference in the litter decomposition could be due to the difference in the grass blades, coarser in tall fescue and finer in perennial ryegrass.
- ❖ We conclude that grass species and endophyte infection had no effect on C sequestration after 7 years of establishment in low input turfgrass system.

## RESULTS...

### LITTER DECOMPOSITION

Table 1. Ranking of means of the proportion of remaining leaf litter

Field Days	0 (6 June 2006)	7 (13 June 2006) ***	14 (20 June 2006) **	21 (27 June 2006) **	35 (11 July 2006)	49 (25 July 2006)	63 (8 August 2006)
Grass Species	Proportion of remaining litter (Mean ± SEM)						
TF-	0.97 ± 0.01 a	0.78 ± 0.01 a	0.73 ± 0.02 a	0.56 ± 0.03 ab	0.44 ± 0.04 a	0.32 ± 0.04 a	0.29 ± 0.01 a
TF+	0.92 ± 0.03 a	0.79 ± 0.02 a	0.69 ± 0.03 ab	0.57 ± 0.02 a	0.43 ± 0.04 a	0.36 ± 0.05 a	0.36 ± 0.04 a
PR-	0.96 ± 0.02 a	0.72 ± 0.03 ab	0.63 ± 0.01 bc	0.51 ± 0.02 bc	0.40 ± 0.01 a	0.34 ± 0.01 a	0.30 ± 0.03 a
PR+	0.93 ± 0.03 a	0.70 ± 0.04 b	0.59 ± 0.02 c	0.47 ± 0.01 c	0.35 ± 0.02 a	0.32 ± 0.03 a	0.25 ± 0.03 a

PROC GLM (SAS). \*\*\*, \*\* significant at  $p < 0.1$  and  $p < 0.05$ . Values followed by the same letter in a column do not differ statistically.

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